

# **Natural Conditions Assessment for Low Dissolved Oxygen, Masons Mill Swamp in Middlesex County, Virginia**



**Submitted by  
Virginia Department of Environmental Quality**

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## Executive Summary

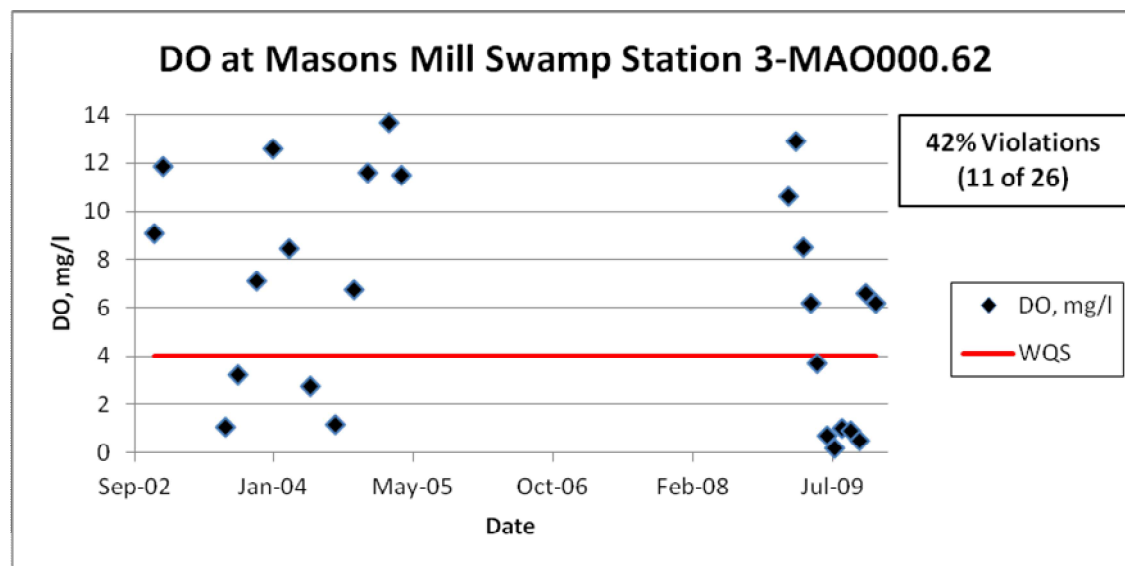
This report presents the assessment of whether low dissolved oxygen (DO) in Masons Mill Swamp is due to natural conditions or whether a Total Maximum Daily Load (TMDL) must be performed because of anthropogenic impacts. Masons Mill Swamp is located within Middlesex County, Virginia, and is a minor tributary to the Rappahannock River. The waterbody identification (WBID) code for Masons Mill Swamp is VAP-E25R. Masons Mill Swamp encompasses a total of approximately 19.34 rivermiles (National Hydrography Dataset (NHD)). Masons Mill Swamp was listed as impaired due to violations in water quality standards for DO. Mason Mill Swamp was previously also assessed as impaired for low pH, but data from 2009 showed that pH is no longer impaired. This report addresses both the DO impairment.

The total area of the Masons Mill Swamp watershed is approximately 7.91 square miles. The average annual rainfall is 45 inches.

The mainstem of Masons Mill Swamp was listed as impaired for on Virginia's 2002 303(d) Total Maximum Daily Load Priority List and Report, and the 2006, 2008, and 2010 305(b) / 303(d) Integrated Reports (VADEQ, 2006, 2008, and 2010) due to violations of the State's water quality standard for DO. The mainstem has also been listed as impaired for low DO on Virginia's draft 2012 Integrated Report. This report evaluates both the DO impairment by determining if natural conditions are the cause of the impairment, thus obviating the need for a TMDL. The mainstem of Mason Mill Swamp was previously assessed as impaired for low pH in 2004, however, additional monitoring in 2009 confirmed that the pH is no longer impaired, and Masons Mill Swamp will be de-listed for pH in the 2012 IR report.

DEQ monitored one station on Masons Mill Swamp with dates ranging from July 1995 through December 2009. Of the 26 total DO data points recorded, 11 violated water quality standards for DO (42%). Figure E1 shows DO concentrations at the listing station 3-MAO000.62.

**Figure E1. pH concentrations at Masons Mill Swamp station 3-MAO000.62.**



According to Virginia Water Quality Standards (9 VAC 25-260-10A), "all state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might be reasonably expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish)."

As indicated above, Masons Mill Swamp must support all designated uses and meet all applicable criteria. If the waterbody violates the instantaneous DO water quality standard of 4.0 mg/l or pH values are less than 6.0 or greater than 9.0 in more than 10.5 percent of samples, the waterbody is classified as impaired and natural conditions must be determined or a TMDL must be developed and implemented to bring the waterbody into compliance with the water quality criterion.

In 2003 VADEQ proposed a methodology for determining whether low DO or pH originates from natural or anthropogenic sources, adapted from "Methodology for Assessing Natural Dissolved Oxygen and pH Impairments: Application to the Appomattox River Watershed, Virginia" (MapTech 2003).

The level of dissolved oxygen in a water body is determined by a balance between oxygen-depleting processes (e.g., decomposition and respiration) and oxygen restoring processes (e.g., aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen-depleting processes. Conditions that would typically be associated with naturally low DO include slow-moving, ripple-less waters where the bacterial decay of organic matter depletes DO at a faster rate than it can be replenished. Indicators of these conditions include low slope, the presence of swamps or wetlands. These conditions often also produce low pH due to organic acids (tannins, humic and fulvic substances) produced in the decay process. These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems.

The general approach to determine if DO and pH impairments in free-flowing streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or low pH levels and for determining the likelihood of anthropogenic impacts is described below. DEQ staff use this approach to implement State Water Control Law 9 VAC 25-260-55, Implementation Procedure for Dissolved Oxygen Criteria in Waters Naturally Low in Dissolved Oxygen.

Before implementing this procedure, all DO and pH data should be screened for flows less than the 7Q10. DO and pH data collected on days when flow was < 7Q10 should be eliminated from the data set and the violation rate recalculated accordingly.

- Step 1. Determine slope and appearance (presence of wetlands).
- Step 2. Determine nutrient levels and compare with USGS background concentrations.
- Step 3. Determine degree of seasonal fluctuation (for DO only).
- Step 4. Determine anthropogenic impacts from permitted dischargers and land use.

No Masons Mill Swamp pH or DO water quality data, standard violations or non-violations were obtained at flows below 7Q10, therefore no data were removed.

The slope of Masons Mill Swamp was determined to be 0.35% slope. This is lower than the defined low slope criteria of 0.50%. Decomposition of the large inputs of decaying vegetation from areas of forested land with swamps, aquatic vegetation and/or heavy tree canopy throughout the watersheds increase oxygen demand and lower DO as they decay, as well as contribute to the low pH by creation of natural weak organic acids (tannic, humic and fulvic acids) during decomposition of the decaying vegetation. These are not considered anthropogenic impacts.

The average nitrate and total nitrogen concentrations were below the USGS (1999) national background nutrient concentrations in streams from undeveloped areas, with levels of nitrate < 0.6 mg/l and TN < 0.1 mg/l. These low nutrient levels are not indicative of human impact. However, the average total phosphorus (TP) of 0.196 mg/l was 96% higher than the USGS (1999) background TP value of <0.1 mg/l. The inorganic orthophosphorus was almost 0.1 mg/l, so that both the inorganic and organic P were approximately equal to the background value for TP. The organic P is produced by decay of plant material. There are no permitted dischargers in the small watershed, which is primarily forested above the listing station. There was one sample date, July 13, 2009, with a TP of 1.12 mg/L. The flow of Masons Mill Swamp on this date was estimated to be very low at 0.54 cfs. The low flow during this sample translated into a low TP load to the watershed. Therefore this high TP was deemed not to have a large impact on overall TP load in the watershed. There are 101 homes in the watershed, 56 of which pre-date 1973. Some of these may have failing septic systems, however almost all of the homes are far from Masons Mill Swamp. Agricultural pasture and cropland comprise only 12% of the watershed. The lack of dischargers, homes close to the impaired waterbody and small amount of agricultural use provide no obvious anthropogenic source of TP in the watershed, such that the high TP appears to be a natural occurrence. Therefore DEQ concluded that the high TP should not preclude designation of Masons Mill Swamp as Class VII Swampwater.

Masons Mill Swamp exhibits natural seasonal DO fluctuation due to the inverse relationship between water temperature and DO.

There are no active permitted point source dischargers in the Masons Mill Swamp watershed.

The watershed is approximately 5062 acres (7.91 mi<sup>2</sup>) in size and is predominately forested (66 percent). Agriculture comprises 12 percent of the watershed, with 7 percent cropland and 5 percent pasture/hayland. Urban areas compose approximately 4 percent of the land base. The remaining 18 percent of the watershed is comprised of 11 percent other grasses and 7 percent wetlands. Land use was not considered to have significantly impacted the swampwater conditions of Masons Mill Swamp.

Based on the above information, a change in the water quality standards classification to Class VII Swampwater due to natural conditions, rather than a TMDL, is indicated for Masons Mill Swamp for a total of 3.36 rivermiles.

DEQ performed the assessment of the Masons Mill Swamp low DO natural condition in lieu of a TMDL. Therefore neither a TMDL Technical Advisory Committee (TAC) meeting nor a public meeting was involved. Public participation will occur during the next water quality standards triennial review process.

## **1. Introduction**

Masons Mill Swamp is located within Middlesex County, Virginia, and is a minor tributary of the Rappahannock River. There are 19.34 total stream miles in the Masons Mill Swamp watershed (National Hydrography Dataset (NHD)) using GIS. The impaired segment for low DO is 3.36 miles in length, the entire mainstem of Masons Mill Swamp. Masons Mill Swamp generally flows northeast from the headwaters south of Laneview, VA, to the confluence with the Rappahannock River downstream of Rt. 604 at Bayport, VA. The watershed totals approximately 7.91 mi<sup>2</sup>. There is no continuous flow gaging station on Masons Mill Swamp.

## **2. Physical Settings**

### **2.1. Listed Water Bodies**

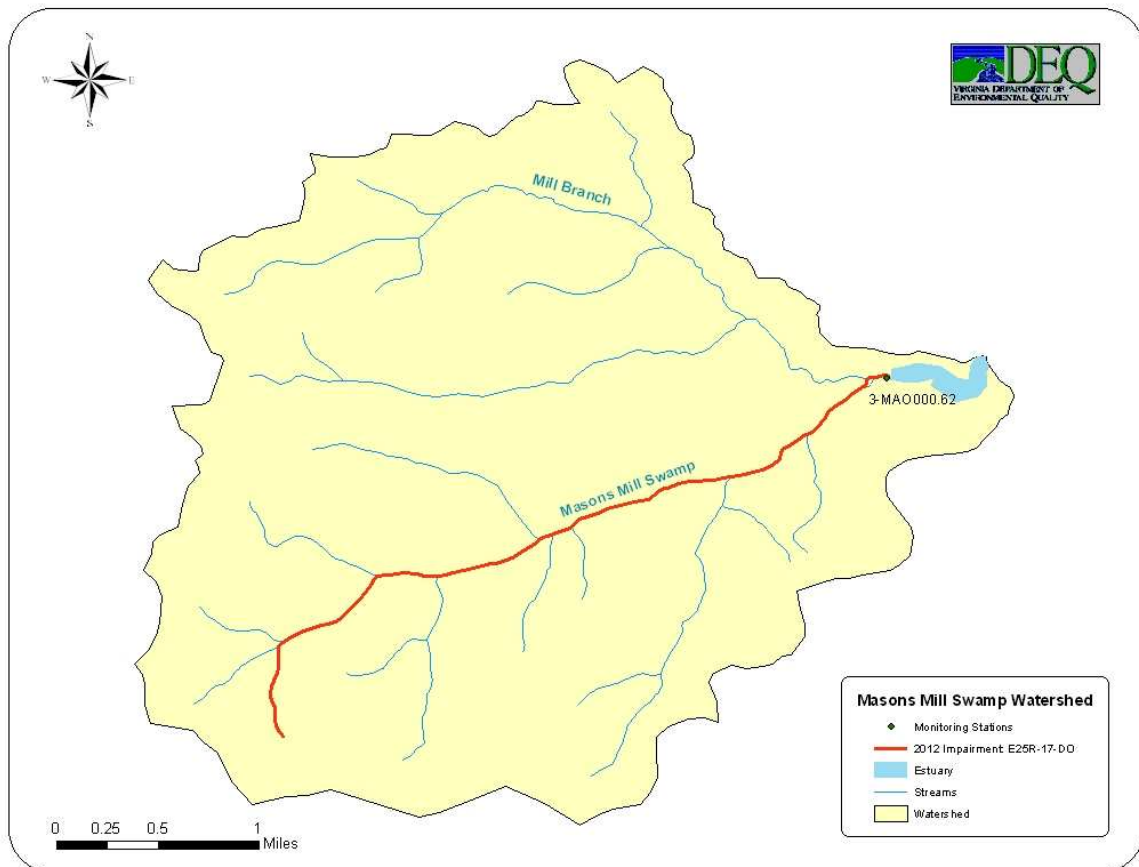
The mainstem of Masons Mill Swamp was listed as impaired for on Virginia's 2002 303(d) Total Maximum Daily Load Priority List and Report, and the 2006, 2008, and 2010 305(b) / 303(d) Integrated Reports (VADEQ, 2006, 2008, and 2010) due to violations of the State's water quality standard for DO. The mainstem has also been listed as impaired for low DO on Virginia's draft 2012 Integrated Report. This report evaluates both the DO impairment by determining if natural conditions are the cause of the impairment, thus obviating the need for a TMDL. The mainstem of Mason Mill Swamp was previously assessed as impaired for low pH in 2004, however, additional monitoring in 2009 confirmed that the pH is no longer impaired, and Masons Mill Swamp will be de-listed for pH in the 2012 IR report. The waterbody identification code (WBID, Virginia Hydrologic Unit) for non-tidal Masons Mill Swamp is VAP-E25R.

### **2.2. Watershed**

#### **2.2.1. General Description**

Masons Mill Swamp flows northeast from the headwaters between Laneview and Jamaica, VA, to the confluence with the Rappahannock River downstream of Rt. 604 at Bayport, VA. The watershed totals approximately 7.91 mi<sup>2</sup>. There is no continuous flow gauging station on Masons Mill Swamp. See Figure 1 for a map of the watershed including monitoring stations.

**Figure 1. The Masons Mill Swamp watershed map and associated monitoring stations.**



## 2.2.2. Geology, Climate, Land Use

### **Geology and Soils**

The impaired segment of Masons Mill Swamp is predominately within the Atlantic Coastal Plain physiographic region. The Atlantic Coastal Plain is the easternmost of Virginia's physiographic provinces. The Atlantic Coastal Plain extends from New Jersey to Florida, and includes all of Virginia east of the Fall Line. The Fall Line is the easternmost extent of rocky river rapids, the point at which east-flowing rivers cross from the hard, igneous and metamorphic rocks of the Piedmont to the relatively soft, unconsolidated strata of the Coastal Plain. The Coastal Plain is underlain by layers of Cretaceous and younger clay, sand, and gravel that dip gently eastward. These layers were deposited by rivers carrying sediment from the eroding Appalachian Mountains to the west. As the sea level rose and fell, fossiliferous marine deposits were interlayered with fluvial, estuarine, and beach strata. The youngest deposits of the Coastal Plain are sand, silt and mud presently being deposited in our bays and along our beaches ([http://www.dcr.virginia.gov/natural\\_heritage/documents/overviewPhysiography\\_vegetation.pdf](http://www.dcr.virginia.gov/natural_heritage/documents/overviewPhysiography_vegetation.pdf)).

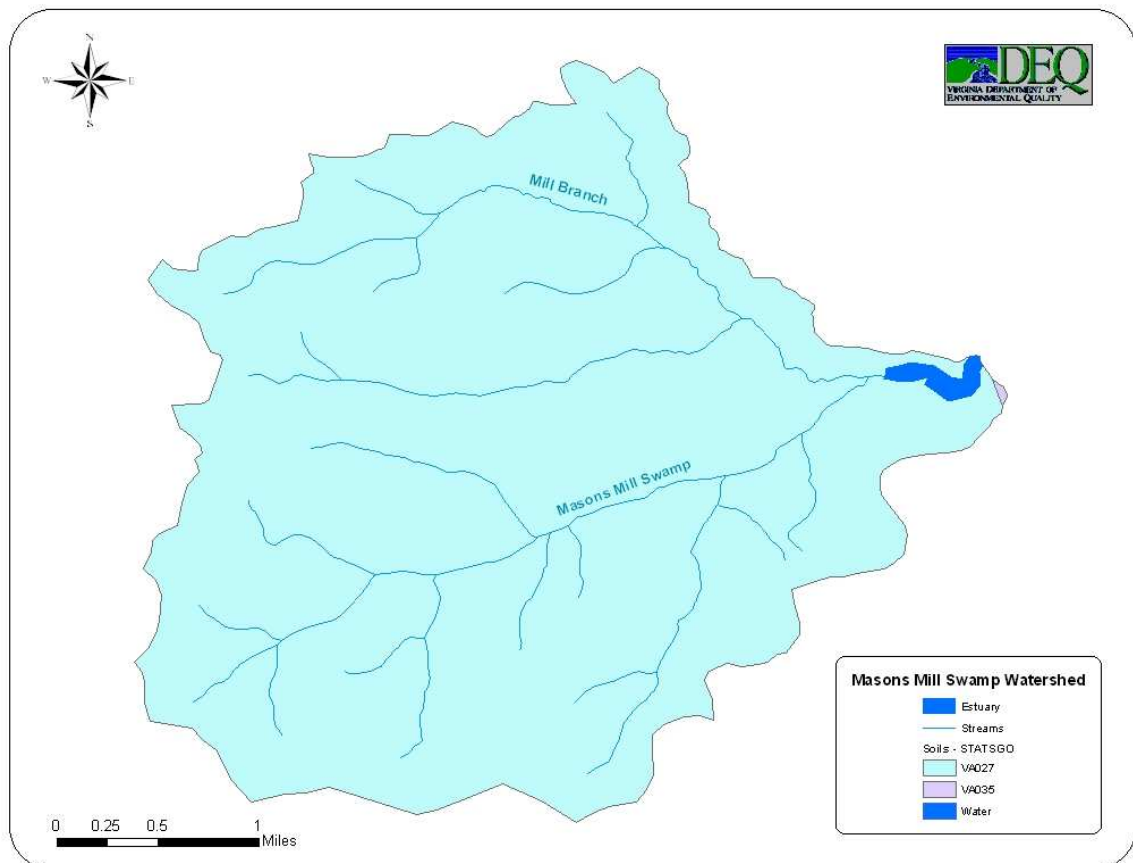
Soils for the Masons Mill Swamp watershed were documented utilizing the VA State Soil Geographic Database (STATSGO). Two general soil types were identified using in this database. Descriptions of these soil series were derived from queries to the USDA Natural Resources Conservation Service (NRCS) Official Soil Series Description web site (<http://soils.usda.gov/technical/classification/osd/index.html>). Figure 2 shows the location of these general soil types in the watershed.

Soils of the Emporia-Johnston-Kenansville-Remlik-Rumford-Slagle-Suffolk-Tomotley (VA027) series are very deep to deep, and vary between well drained to poorly drained with moderately slow or slow permeability.

They formed in moderately fine-textured stratified fluvial and marine sediments on the upper Coastal Plain and stream terraces.

The soils of the Craven-Mattaponi-Lenoir-Coxville (VA035) series are very deep in which the drainage ranges from somewhat poor to well drained and the permeability is typically slow to moderately slow. The soils formed in flats or depressions from the lower to upper Coastal Plain and Piedmont Physiographic Provinces of the Atlantic Coast, in which the parent materials consists of fluvial and marine sediments.

**Figure 2. Soil Characteristics of the Masons Mill Swamp Watershed.**



### ***Climate***

The climate summary for Masons Mill Swamp comes from a weather station located in West Point, VA (449025) with a period of record from 1954 to 2010. The average annual maximum and minimum temperatures (°F) at the weather station are 69.8 and 47.0 and the annual rainfall (inches) is 45.30 (Table 1) (Southeast Regional Climate Center, [http://www.sercc.com/climateinfo/historical/historical\\_va.html](http://www.sercc.com/climateinfo/historical/historical_va.html)).

**Table 1. Climate summary for West Point, Virginia (449025).**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
<b>Average Max. Temperature (F)</b>	47.8	51.1	60.3	71.3	78.7	85.9	89.3	87.7	81.7	71.3	61.6	51.1	69.8
<b>Average Min. Temperature (F)</b>	27.3	29.1	36.0	45.1	54.3	62.8	67.0	66.0	59.2	47.7	38.7	30.4	47.0



Natural Conditions Assessment for Masons Mill Swamp

<b>Average Total Precipitation (in.)</b>	3.48	3.12	4.01	3.26	3.91	3.82	4.85	4.66	4.19	3.47	3.21	3.35	45.30
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**Land Use**

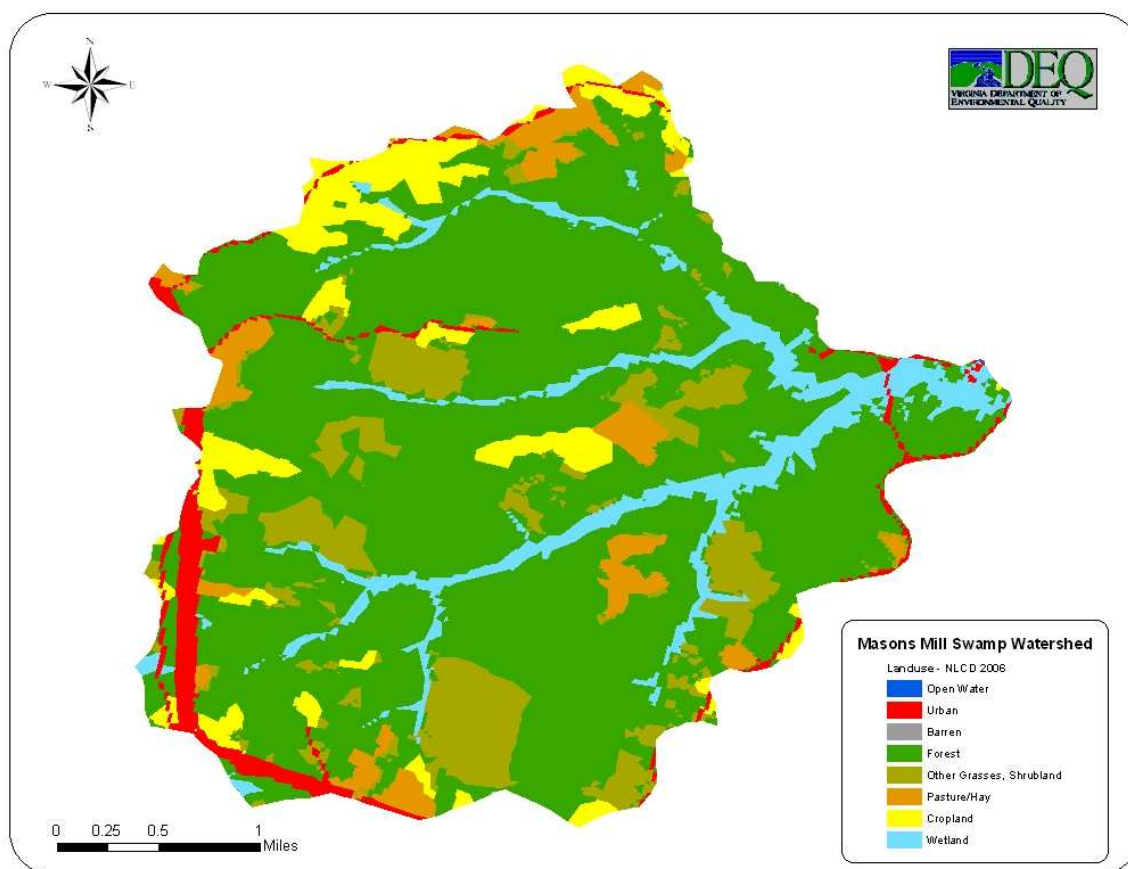
The Masons Mill Swamp watershed extends from approximately just east of Laneview, VA, to approximately 0.5 miles east of Bayport, VA. It is approximately 3.0 miles long and 2.5 miles wide. The watershed is approximately 5062 acres (7.91 mi<sup>2</sup>) in size and is predominately forested (66 percent). Agriculture comprises 12 percent of the watershed, with 7 percent cropland and 5 percent pasture/hayland. Urban areas compose approximately 4 percent of the land base. The remaining 18 percent of the watershed is comprised of 11 percent other grasses and 7 percent wetlands. Land use is described in Table 2. Percent of land use type is affected by rounding.

A map of the distribution of land use in the watershed (Figure 3) shows that urban land use is concentrated around Rt.17 near the western headwaters and wetlands are concentrated along the mainstem in the eastern central portion of the watershed.

**Table 2. Land Use in the Masons Mill Swamp Watershed**

<b>Land Use Type</b>	<b>Acres</b>	<b>Square Miles</b>	<b>Percent</b>
Open Water	0.00	0.00	0%
Urban	186	0.29	4%
Barren or Mining	0.00	0.00	0%
Transitional	0.00	0.00	0%
Forest	3354	5.24	66%
Agri - Pasture	230	0.36	5%
Agri - Cropland	352	0.55	7%
Other Grasses	576	0.90	11%
Wetland	365	0.57	7%
<b>Totals:</b>	<b>5062</b>	<b>7.91</b>	<b>100%</b>

**Figure 3. Land Use in the Masons Mill Swamp Watershed**



### 3. Description of Water Quality Problem/Impairment

The mainstem of Masons Mill Swamp was listed as impaired on Virginia's 2006 303(d) Total Maximum Daily Load Priority List and Report, and the 2008, and 2010 305(b) / 303(d) Integrated Reports (VADEQ, 2006, 2008, and 2010) due to violations of the State's water quality standard for DO. The mainstem has also been listed as impaired for low DO on Virginia's draft 2012 Integrated Report. The mainstem of Mason Mill Swamp was previously assessed as impaired for low pH in 2004, however, additional monitoring in 2009 confirmed that the pH is no longer impaired, and Masons Mill Swamp will be de-listed for pH in the 2012 IR report. This report evaluates the DO impairment by determining if natural conditions are the cause of the impairment, thus obviating the need for a TMDL.

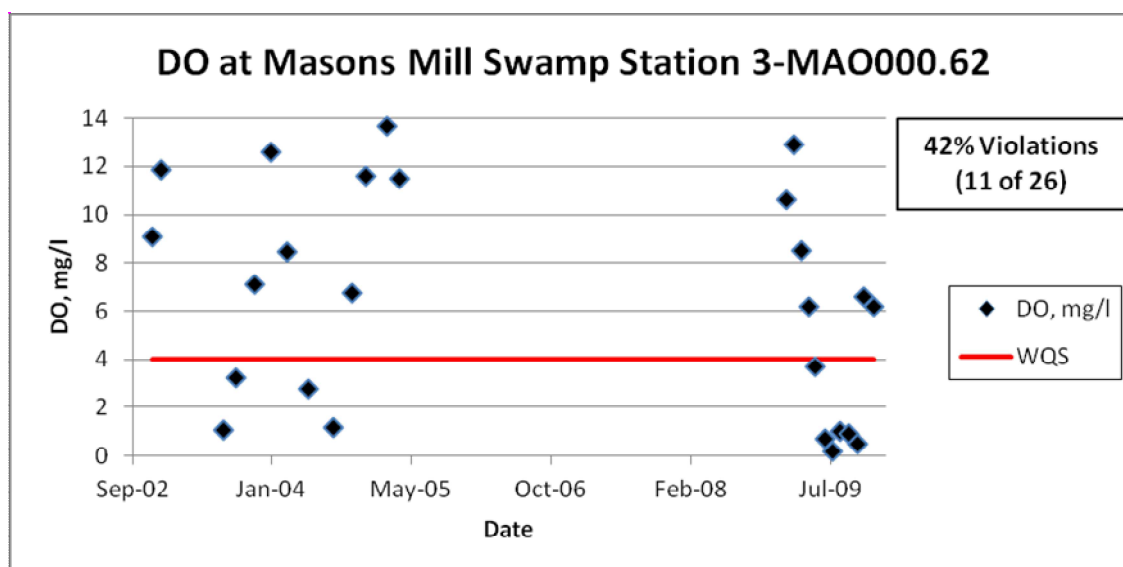
DEQ monitored one station on Masons Mill Swamp (Figure 1) with dates ranging from July 1995 through December 2009. Of the 26 total DO data points recorded, 11 violated water quality standards for DO (42%). The DO minimum and maximum values ranged from 0.2 to 13.65 mg/l. The results are summarized in Table 3.

**Table 3. DO data collected by DEQ from 1 station on Masons Mill Swamp.**

		Number of Samples		SU		mg/l		Number of Violations	
Station	Sample Period	pH	DO	Average pH	Min-Max pH	Average DO	Min-Max DO	pH	DO
3-MAO000.62	7/14/1995 to 12/7/2009	26	26	6.35	5.58 – 7.7	6.14	0.2 – 13.65	6	11

Time series graphs of all DO data collected at the original listing station, Masons Mill Swamp at station 3-MAO000.62, shows the DO ranging from 0.2 mg/l to 13.65 mg/l (Figure 4). The horizontal red line at the DO = 4.0 mark represents the minimum water quality standard in Figure 4. The data points below the DO = 4.0 line are violations of the water quality standard in Figure 4.

**Figure 4. Time series of DO at Masons Mill Swamp station 3-MAO000.62, minus 7/14/95 DO 0.73 mg/l.**



### 3.1 Associated pH and DO of Masons Mill Swamp

DEQ monitored no other pH and DO stations on Masons Mill Swamp because station 3-MAO000.62 at Rt. 604 was the only bridge crossing in the small watershed.

## 4. Water Quality Standard

According to Virginia Water Quality Standards (9 VAC 25-260-5), the term “water quality standards means provisions of state or federal law which consist of a designated use or uses for the waters of the Commonwealth and water quality criteria for such waters based upon such uses. Water quality standards are to protect the public health or welfare, enhance the quality of water and serve the purposes of the State Water Control Law (§62.1-44.2 et seq. of the Code of Virginia) and the federal Clean Water Act (33 USC §1251 et seq.).”

As stated above, Virginia water quality standards consist of a designated use or uses and water quality criteria. These two parts of the applicable water quality standard are presented in the sections that follow.

### 4.1. Designated Uses

According to Virginia Water Quality Standards (9 VAC 25-260-10A), “all state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might be reasonably expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish).”

As stated above, Masons Mill Swamp must support all designated uses and meet all applicable criteria.

## 4.2. Applicable Water Quality Criteria

The applicable water quality criteria for DO and pH in the Masons Mill Swamp watershed are an instantaneous minimum DO of 4.0 mg/l and pH from 6.0 SU to 9.0 SU, as in Table 4.

Table 4. Applicable water quality standards		
Parameter	Minimum, mg/l	Maximum, mg/l
pH	6.0	9.0
DO	4.0	-

If the waterbody exceeds the criterion listed above in more than 10.5 percent of samples, the waterbody is classified as impaired and natural conditions must be determined or a TMDL must be developed and implemented to bring the waterbody into compliance with the water quality criterion.

## 5. Assessment of Natural Conditions Affecting low DO - Process for determining if DO and pH impairments in free-flowing streams are due to natural conditions.

The level of dissolved oxygen in a water body is determined by a balance between oxygen-depleting processes (*e.g.*, decomposition and respiration) and oxygen-restoring processes (*e.g.*, aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen-depleting processes. The level of pH in a water body is determined by a balance between organic acids produced by decay of vegetative material, and buffering capacity. Conditions in a stream that would typically be associated with naturally low DO and pH include slow-moving, ripple-less waters or wetlands where the decay of organic matter produces organic acids. These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems. The general approach to determine if DO and pH impairments in streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or pH levels and for determining the likelihood of anthropogenic impacts that will exacerbate the natural condition is described below.

- Step 1. Determine slope and appearance.
- Step 2. Determine nutrient levels.
- Step 3. Determine degree of seasonal fluctuation (for DO only).
- Step 4. Determine anthropogenic impacts.

**The results from this methodology (or process or approach) will be used to determine if the stream should be re-classified as Class VII Swamp Waters. Each step is described in detail below.**

## Procedure for Natural Condition

# Assessment of low pH and low DO in Virginia Streams

Prepared by Virginia Department of Environmental Quality  
October 2004

## I. INTRODUCTION

Virginia's list of impaired waters currently shows many waters not supporting the aquatic life use due to exceedances of pH and/or DO criteria that are designed to protect aquatic life in Class III waters. However, there is reason to believe that most of these streams or stream segments have been mis-classified and should more appropriately be classified as Class VII, Swamp Waters. This document presents a procedure for assessing if natural conditions are the cause of the low pH and/or low DO levels in a given stream or stream segment.

The level of dissolved oxygen (DO) in a water body is determined by a balance between oxygen-depleting processes (*e.g.*, decomposition and respiration) and oxygen-restoring processes (*e.g.*, aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen-depleting processes. The level of acidity as registered by pH in a water body is determined by a balance between organic acids produced by decay of vegetative material, and buffering capacity.

Conditions in a stream that would typically be associated with naturally low DO and/or naturally low pH include slow-moving, ripple-less waters. In such waters, the decay of organic matter depletes DO at a faster rate than it can be replenished and produces organic acids (tannins, humic and fulvic substances). These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems.

The general approach to determine if DO and pH impairments in streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or pH levels and for determining the likelihood of anthropogenic impacts that will exacerbate the natural condition is described below. DEQ staff is proposing to use this approach to implement State Water Control Law 9 VAC 25-260-55, Implementation Procedure for Dissolved Oxygen Criteria in Waters Naturally Low in Dissolved Oxygen.

Waters that are shown to have naturally low DO and pH levels will be re-classified as Class VII, Swamp Waters, with the associated pH criterion of 4.3 to 9.0 SU. An associated DO criterion is currently being developed from swamp water data. A TMDL is not needed for

these waters. An assessment category of 4C will be assigned until the waterbody has been re-classified.

## **II. NATURAL CONDITION ASSESSMENT**

Following a description of the watershed (including geology, soils, climate, and land use), a description of the DO and/or pH water quality problem (including a data summary, time series and monthly data distributions), and a description of the water quality criteria that were the basis for the impairment determination, the available information should be evaluated in four steps.

### **Step 1. Determine appearance and flow/slope.**

Streams or stream segments that have naturally low DO (< 4 mg/L) and low pH (< 6 SU) are characterized by very low slopes and low velocity flows (flat water with low reaeration rates). Decaying vegetation in such swampy waters provides large inputs of plant material that consumes oxygen as it decays. The decaying vegetation in swamp water also produces acids and decreases pH. Plant materials contain polyphenols such as tannin and lignin. Polyphenols and partially degraded polyphenols build up in the form of tannic acids, humic acids, and fulvic acids that are highly colored. The trees of swamps have higher polyphenolic content than the soft-stemmed vegetation of marshes. Swamp streams (blackwater) are therefore more highly colored and more acidic than marsh streams.

Appearance and flow velocity (or slope if flow velocity is not available) must be identified for each stream or stream segment to be assessed for natural conditions and potential re-classification as Class VII swamp water. This can be done through maps, photos, field measurements or other appropriate means.

### **Step 2. Determine nutrient levels.**

Excessive nutrients can cause a decrease in DO in relatively slow moving systems, where aeration is low. High nutrient levels are an indication of anthropogenic inputs of nitrogen, phosphorus, and possibly organic matter. Nutrient input can stimulate plant growth, and the resulting die-off and decay of excessive plankton or macrophytes can decrease DO levels.

USGS (1999) estimated national background nutrient concentrations in streams and groundwater from undeveloped areas. Average nitrate background concentrations are less than 0.6 mg/L for streams, average total nitrogen (TN) background concentrations are less than 1.0 mg/L, and average background concentrations of total phosphorus (TP) are less than 0.1 mg/L.

Nutrient levels must be documented for each stream or stream segment to be assessed for natural conditions and potential re-classification as Class VII swamp water. Streams with average concentrations of nutrients greater than the national background concentrations should be further evaluated for potential impacts from anthropogenic sources.

### **Step 3. Determine degree of seasonal fluctuation (for DO only).**

Anthropogenic impacts on DO will likely disrupt the typical seasonal fluctuation seen in the DO concentrations of wetland streams. Seasonal analyses should be conducted for each potential Class VII stream or stream segment to verify that DO is depressed in the summer months and recovers during the winter, as would be expected in natural systems. A weak seasonal pattern could indicate that human inputs from point or nonpoint sources are impacting the seasonal cycle.

#### Step 4. Determine anthropogenic impacts.

Every effort should be made to identify human impacts that could exacerbate the naturally low DO and/or pH. For example, point sources should be identified and DMR data analyzed to determine if there is any impact on the stream DO or pH concentrations. Land use analysis can also be a valuable tool for identifying potential human impacts.

Lastly, a discussion of acid rain impacts should be included for low pH waters. The format of this discussion can be based either on the process used for the recent Class VII classification of several streams in the Blackwater watershed of the Chowan Basin (letter from DEQ to EPA, 14 October 2003). An alternative is a prototype regional stream comparison developed for Fourmile Creek, White Oak Swamp, Matadequin Creek and Mechumps Creek (all east of the fall line). The example analysis under IV in this document, or the example report prepared for Fourmile Creek, illustrate this approach. For streams west of the fall line, a regional stream comparison for 2004 analyses encompasses Winticomack, Winterpock, and Chickahominy Rivers.

#### 7Q10 Data Screen

If the data warrant it, a data screen should be performed to ensure that the impairment was identified based on valid data. All DO or pH data that violate water quality standards should be screened for flows less than the 7Q10. Data collected on days when flow was < 7Q10 should be eliminated from the data set and the violation rate recalculated accordingly. Only those waters with violation rates determined days with flows > or = 7Q10 flows should be classified as impaired.

In some cases, data were collected when flow was 0 cfs. If the 7Q10 is identified as 0 cfs as well, all data collected under 0 cfs flow would need to be considered in the water quality assessment. In those cases, the impairment should be classified as 4C, impaired due to natural conditions, no TMDL needed. However, a reclassification to Class VII may not always be appropriate.

### **III. NATURAL CONDITION CONCLUSION MATRIX**

The following decision process should be applied for determining whether low pH and/or low DO values are due to natural conditions and justify a reclassification of a stream or stream segment as Class VII, Swamp Water.

If velocity is low or if slope is low (<0.50%) AND  
If wetlands are present along stream reach AND

If no point sources or only point sources with minimal impact on DO and pH AND  
If nutrients are < typical background

- ❖ average (= assessment period mean) nitrate less than 0.6 mg/L
- ❖ average total nitrogen (TN) less than 1.0 mg/L, and
- ❖ average total phosphorus (TP) are less than 0.1 mg/L AND

For DO: If seasonal fluctuation is normal AND

For pH: If nearby streams without wetlands meet pH criteria OR if no correlation between in-stream pH and rain pH,

THEN determine as impaired due to natural condition

→ assess as category 4C in next assessment

→ initiate WQS reclassification to Class VII Swamp Water

→ get credit under consent decree

The analysis must state the extent of the natural condition based on the criteria outlined above. A map showing land use, point sources, water quality stations and, if necessary, the delineated segment to be classified as swamp water should be included.

In cases where not all of these criteria apply, a case by case argument must be made based on the specific conditions in the watershed.

### 5.1 Preliminary Data Screen for Low Flow 7Q10

The 7Q10 flow of a stream is the lowest streamflow for seven consecutive days that occurs on average once every ten years. The first step for low flow 7Q10 screening is to determine the most accurate 7Q10 available. The 7Q10 flow for Masons Mill Swamp may be estimated by a drainage area ratio of the Masons Mill Swamp watershed (7.91 mi<sup>2</sup>) with the 7Q10 flow at the long-term continuous gauging station Piscataway Creek near Tappahannock, VA, (USGS:01669000), with a drainage area of 28.0 mi<sup>2</sup> and a 7Q10 of 0.50 cfs (2005). Thus the 7Q10 of Masons Mill Swamp is estimated at 0.14 cfs.

The DO Instantaneous Water Quality Standard applies **AT** 7Q10 flow, but **NOT** below 7Q10 flow (9 VAC 25-260-50 \*\*\*). Therefore in streams where the 7Q10 > 0.0 cfs, DO less than 4.0 mg/l taken at flows below 7Q10 are not water quality standard violations. However, in streams where the 7Q10 = 0.0 cfs, **ALL** DO data < 4.0 mg/l are standard violations, even if the flow = 0 cfs when the DO was taken.

No Masons Mill pH or DO water quality data were obtained at flows below 7Q10, therefore no data were removed.

### 5.2 Low slope, Swamps, Wetlands or Large Forested Areas

The slope of Masons Mill Swamp was determined to be 0.35% slope (Table 5). This is lower than the defined low slope criteria of 0.50%. Decomposition of the large inputs of decaying vegetation from areas of forested land with swamps and heavy tree canopy throughout the watersheds increase oxygen demand and lower DO as they decay, as well as contribute to the low pH by creation of natural weak organic acids (tannic, humic and fulvic acids) during decomposition of the decaying vegetation. These are not considered anthropogenic impacts.

**Table 5. Calculated percent slope for Masons Mill Swamp.**

Stream	% Slope	Upstream Elevation (Feet) at Rivermile (RM)	Downstream Elevation (Feet) at Rivermile (RM)
Masons Mill Swamp	0.35	40' at RM 3.20	5' at RM 1.31



Visual inspection of Masons Mill Swamp revealed swampy areas with heavy aquatic vegetation. Decomposition of vegetative matter from large swampy areas lowers DO and pH as decay occurs. (Figure 5).

**Figure 5. Masons Mill Swamp, Rt. 604, Upstream.**



### **5.3 Instream Nutrients**

The VADEQ collected nutrient data from the original listing station 3-MAO000.62 (January to December 2009 (Table 6). The average nitrate and total nitrogen concentrations were below the USGS (1999) national background nutrient concentrations in streams from undeveloped areas, with levels of nitrate < 0.6 mg/l and TN < 0.1 mg/l. These low nutrient levels are not indicative of human impact. The average total phosphorus (TP) of 0.196 mg/l was 96% higher than the USGS (1999) background TP value of <0.1 mg/l. The inorganic orthophosphorus was almost 0.1 mg/l by itself, so that both the inorganic and organic P were approximately equal to the background value for TP. The organic P is produced by decay of plant material. There was one sample date, July 13, 2009, with a TP of 1.12 mg/L. The flow of Masons Mill Swamp on this date was estimated to be 0.54 cfs by drainage ratio comparison with Piscataway Creek. The low flow translated into a low TP load to the watershed. Therefore this high TP was deemed not to have a large impact on overall TP load in the watershed. There are no permitted dischargers in the small watershed, which is primarily forested above the listing station. There are 101 homes in the watershed (aerial photo 2006-7), 56 of which pre-date 1973 from topographic maps. Some of these may have failing septic systems, however almost all of the homes are far from Masons Mill Swamp. Agricultural pasture and cropland comprise only 12% of the watershed. The lack of dischargers, homes close to the impaired waterbody and small amount of agricultural use provide no obvious anthropogenic source of TP in the watershed, such that the high TP appears to be a natural occurrence. Therefore DEQ concluded that the high TP should not preclude designation of Masons Mill Swamp as Class VII Swampwater.

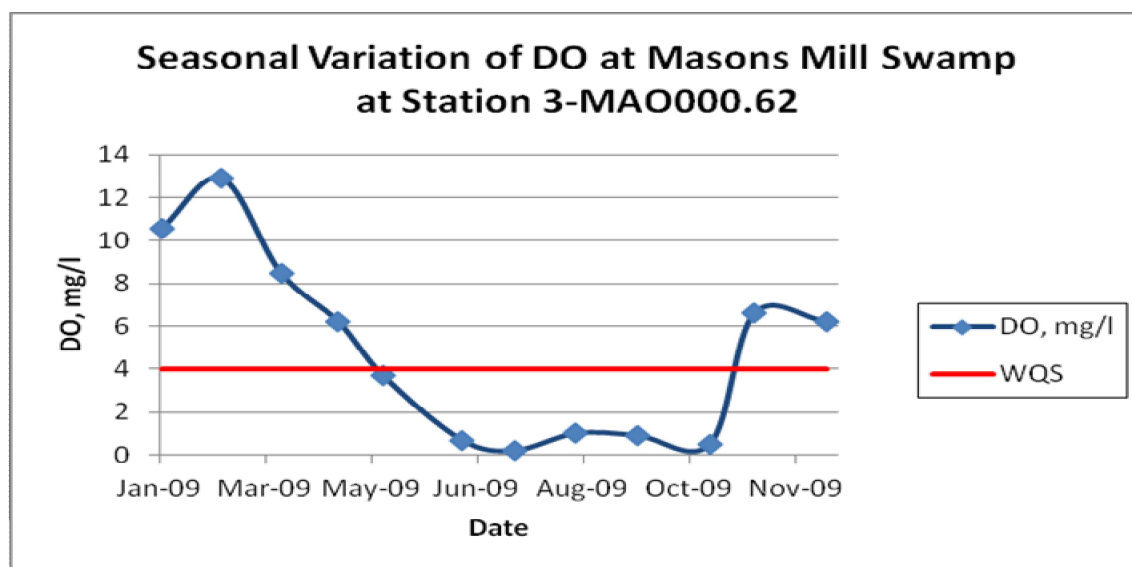
**Table 6. Instream Nutrients of Masons Mill Swamp at 3-MAO000.62**

Parameter	Average Conc.	Number
<b>Total Phosphorus</b>	<b>0.196 mg/l</b>	(n=12) (96% above USGS background)
Orthophosphorus	0.092 mg/l	(n=12)
Total Kjeldahl Nitrogen	0.858 mg/l	(n=12)
Ammonia as N	0.051 mg/l	(n=12)
<b>Nitrate as N</b>	<b>0.027 mg/l</b>	(n=12)
Nitrite as N	0.009 mg/l	(n=12)
<b>TN (TKN + NO<sub>3</sub> + NO<sub>2</sub>)</b>	<b>0.894 mg/l</b>	(n=12)
Nitrite + Nitrate, Total as N	0.035 mg/l	(n=12)

#### 5.4 Natural Seasonal DO Fluctuation

The 2009 DO data collected at the Masons Mill Swamp listing station 3-MAO000.62 were graphed to demonstrate the natural seasonal DO fluctuation due to the inverse relationship between water temperature and DO. DO is high in the winter months while water temperatures are low, and low in the summer months when water temperatures are high. This is depicted in Figure 6.

**Figure 6. Seasonal DO Variation at Masons Mill Swamp at Rt. 604, January – December 2009.**



#### 5.5 Impact from Point Source Dischargers and Land Use

There are no active permitted point source dischargers in the Masons Mill Swamp watershed.

The watershed is approximately 5062 acres (7.91 mi<sup>2</sup>) in size and is predominately forested (66 percent). Agriculture comprises 12 percent of the watershed, with 7 percent cropland and 5 percent pasture/hayland. Urban areas compose approximately 4 percent of the land base. The remaining 18 percent of the watershed is comprised of 11 percent other grasses and 7 percent wetlands. Land use was not considered to have significantly impacted the swampwater conditions of Masons Mill Swamp.

## 6. CONCLUSION

***The following decision process is proposed for determining whether low DO values are due to natural conditions:***

If slope is low (<0.50) AND

If wetlands or large areas of forested land are present along stream reach AND

If no point sources or point sources with minimal impact on DO AND

If nutrients are < typical background

- ❖ average (= assessment period mean) nitrate less than 0.6 mg/L
- ❖ average total nitrogen (TN) less than 1.0 mg/L, and
- ❖ average total phosphorus (TP) are equal to or less than 0.1 mg/L AND

If nearby streams without wetlands meet DO criteria,

THEN determine as impaired due to natural condition

→ assess as category 4C in next assessment

→ initiate WQS reclassification to Class VII Swamp Water

→ get credit under consent decree

No Masons Mill Swamp DO water quality data, standard violations or non-violations were obtained at flows below 7Q10, therefore no data were removed.

The slope of Masons Mill Swamp was determined to be 0.35% slope. This is lower than the defined low slope criteria of 0.50%. Decomposition of the large inputs of decaying vegetation from areas of forested land with swamps, aquatic vegetation and/or heavy tree canopy throughout the watersheds increase oxygen demand and lower DO as they decay, as well as contribute to the low pH by creation of natural weak organic acids (tannic, humic and fulvic acids) during decomposition of the decaying vegetation. These are not considered anthropogenic impacts.

The average nitrate and total nitrogen concentrations were below the USGS (1999) national background nutrient concentrations in streams from undeveloped areas, with levels of nitrate < 0.6 mg/l and TN < 0.1 mg/l. These low nutrient levels are not indicative of human impact. The average total phosphorus (TP) of 0.196 mg/l was 96% higher than the USGS (1999) background TP value of <0.1 mg/l. The inorganic orthophosphorus was almost 0.1 mg/l by itself, so that both the inorganic and organic P were approximately equal to the background value for TP. The organic P is produced by decay of plant material. There was one sample date, July 13, 2009, with a TP of 1.12 mg/L. The flow of Masons Mill Swamp on this date was estimated to be 0.54 cfs by drainage ratio comparison with Piscataway Creek. The low flow translated into a low TP load to the watershed. There are no permitted dischargers in the small watershed, which is primarily forested above the listing station. There are 101 homes in the watershed (aerial photo 2006-7), 56 of which pre-date 1973 from topographic maps. Some of these may have failing septic systems, however almost all of the homes are far from Masons Mill Swamp. Agricultural pasture and cropland comprise only 12% of the watershed. The lack of dischargers, homes close to the impaired waterbody and small amount of agricultural use provide no obvious anthropogenic source of TP in the watershed, such that the high TP appears to be a natural occurrence. Therefore DEQ concluded that the high TP should not preclude designation of Masons Mill Swamp as Class VII Swampwater.

Masons Mill Swamp exhibits natural seasonal DO fluctuation due to the inverse relationship between water temperature and DO.

There are no active permitted point source dischargers in the Masons Mill Swamp watershed.

The watershed is approximately 5062 acres (7.91 mi<sup>2</sup>) in size and is predominately forested (66 percent). Agriculture comprises 12 percent of the watershed, with 7 percent cropland and 5 percent pasture/hayland. Urban areas compose approximately 4 percent of the land base. The remaining 18 percent of the watershed is comprised of 11 percent other grasses and 7 percent wetlands. Land use was not considered to have significantly impacted the swampwater conditions of Masons Mill Swamp.

Based on the above information, a change in the water quality standards classification to Class VII Swampwater due to natural conditions, rather than a TMDL, is NOT indicated for Masons Mill Swamp located in waterbody identification codes (WBID) VAP-E25R, for a total of 3.36 rivermiles. Masons Mill Swamp in VAP-E25R will receive a non-point source (NPS) load allocation for TP and TN in the approved Chesapeake Bay TMDL. This will obviate the need for a future nutrient-based DO and pH TMDL for the watershed.

DEQ performed the assessment of the Masons Mill Swamp low DO natural condition in lieu of a TMDL. Therefore neither a TMDL Technical Advisory Committee (TAC) meeting nor a public meeting was involved. Public participation will occur during the next water quality standards triennial review process.

## 7. References

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